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A CIRCULARLY POLARIZED DUAL BAND ANTENNA FOR MULTILAYER 5G MOBILE PHONE: A SYSTEMATIC REVIEW

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Abstract:

In today's environment, cellular based mobile communication has been inclining towards the design and developments. The demand created by the incremental mobile data traffic has lowered the efficacy of the designed systems. Henceforth, a new strategy has been explored to design and develop the next generation of cellular communication systems. Right from 1G to 4G, the communication system has introduced many challenges such as low spectral efficiency, low data rates, limited network capacity of cellular networks. The 3G technology upbringing the growth of 4G that resolves the network capacity issue by suggesting reusing spatial technology and the support of multi-antenna transmission systems. However, the quality of network data rate is still in the developmental area. This paper presents the review of a circularly polarized antenna for multilayer 5G mobile phones. The existing techniques are explored from the viewpoint of merits and demerits of its employed antennas usage. The fundamentals of the circular polarization and its benefits are also explained in this study. The survey states the issues such as CPs design; Patch/etched structure; tag based antennas; usability; incorporation of sensing technology; coupling of EM waves and propagation, attenuation and penetration using 5G networks. This review analysis paves the way for upcoming researchers in this field.

Keywords: Cellular networks; Mobile communication system; Wireless system; Antennas; Circular polarized; Usability and 5G networks

1. Introduction

The recent developments made in wireless communications revolutionizes technological advancement. A tremendous amount of data is being generated, monitored and retrieved on different applications. Thus, the growth of smartphones are inclining towards the contents and applications. It has paved the way to increase the flexibility of wireless communications. It reinvents the fields of machine to machine communications and the internet of things where both display the communication between objects by means of the web. In general, the human body is associated with different machines to the environment (Daquan et al, 2013), in order to monitor their health status. The physiological data generated from different parts of the body are collected and then transferred to the intended receiver of the applications. In order to develop easy communications, it is significant to be aware about the propagation of waves along the parts of the human body. And also, how the body reacts to the propagation channel is also to be known. Additionally, it is helpful to know about the transmission of the waves while the antennas are placed near to the body. The placement of the antennas becomes one of the decisive factors of the waves propagation.

The cellular technology has also combined with the new communication trends, so as to break the barriers in inter and intra - communication systems (Asif D. Gandhi et al, 2011). The previous four generations of cellular technology have helped somehow to challenge the communication barriers, however, the innovation made in the 5G cellular generation has offered numerous benefits than previous four generations. It has high frequencies with high network bandwidth even with a limited set of antennas and the base station. Supporting IoT devices, high network speed and energy preservation are the issues thrown by the previous cellular generations. Thus, the 5G generation is introduced to resolve the challenges faced by the previous cellular generations. Inspite of it, 5G generation systems (Pimmy Gandotra et al, 2016) can handle the low network bandwidth with high latency and vice versa. To provide as much as possible the same quality of service everywhere, like the fixed Internet, and will be much more energy efficient.

Antenna systems play a vital role in the wireless communication systems that ensures the network connectivity of the intended systems. As of now, the requirements of antenna design prevailing in the wireless systems are the support of multiband operation; compact size and flexibility toward any applications has gained much attention among the researchers. Despite these advantages, a planar multiband microstrip antenna has been widely deployed in several applications which helps for transmitting the voice, data, video, and multimedia information for multimode communication systems (Ali et al, 2012). Generally, antennas are classified into two classes, namely, planar and non-planar. In general, planar antennas have given much attention because of their low profile and the least fabrication costs. Since the planar antennas make use of different shapes and slots size, it improved the loss, gain and input impedance of the antenna. In order to achieve the radiation pattern from omnidirectional antennas the impedance has been explored by following the planar structure and the coplanar waveguides.

Conventional studies have focussed on narrowband microstrip based antennas that generate radiation of the linear polarization only. The reachability provided by microstrip based antennas has introduced circular polarization oriented antenna design. The circular based antenna has provided much more flexibility and versatility between the transmitter and the receiver. It does not cause any mismatch between the network entities. There are many challenges provided by the antenna designs with regards to the application requirements. Some of them are miniaturized design, polarization mismatch, multipath interferences, radiation stability and electromagnetic interference (EMI) problems (Akpakwu et al, 2017). With the help of printed monopole antennas, the wireless antennas are designed with features like better structure, low profile, lightweight impedance and the omnidirectional radiation patterns. Regardless, radiation patterns of these antennas are linearly polarized based on their usage. The main constraints of the circularly polarized waves are: a) the field must be two orthogonal linear components and b) maintenance of equal magnitude of two components.

Polarization (Mavromoustaksis et al, 2016) is a parameter that applies EM waves to generate useful information about the magnetic lines in an electromagnetic field. It is an important factor in the wireless communication systems. The role of polarization in an antenna corresponds to the radio waves given by the antennas. It emits the radio waves from horizontal and vertical placed antennas. These are the two categories of linear polarization. It is otherwise called the elliptical polarization. It is formed from the combination of linear and circular polarizer effects. In the case of circular polarization, the plane of the antenna rotates in a corkscrew pattern takes a complete revolution from the wavelength estimation. It also radiates energy under planes of vertical and the horizontal placed antennas. If the EM waves generated from the clockwise, then it is called as right hand circular and if it is anti-clockwise, it is called as left hand circular. Then, the benefits of circular polarization are (Giordani et al, 2016):

a) *Immunity towards the rotation of faraday:*

Faraday rotation is a process that revolves near the polarization. It is possible only when the passing of lights via a specified material is exposed to the alignment of propagation waves. It creates trouble when the emitted radio waves went through the ionosphere, which contains an ionized plasma. This ionized plasma is referred to as faraday rotation. In the scenario of linear polarization, it unrelated the signals effects and thus strength of the signal is lost. While in the case of circular polarization, the effects of CP waves increases the signal strength.

b) *Handling of Multipath losses:*

In general, multipath refers to the propagation of exploring the differences in primary and the reflected signals obtained from multiple sources at a time stretch. It gives constructive interference and phase issues. In the viewpoint of CPs, the multipath signals are omitted.

c) Effects of misalignment during polarization:

Depending on the antenna placement, the horizontal and vertical polarization are received. Therefore, the signals emitting by receiver and transmitter should be properly placed, so as to avoid the mismatching of signals. While the circular polarization does not align with the mismatching signals.

d) Weather conditions effect:

Weather constraint is one of the causing factors of signal degradation. The effects of wind, temperature, and water contamination are the main factors that induce changes in reflectivity, absorption, phasing, multi-path and line of sight of the signals. Compared to the LP, the CP is more resilient towards the weather constraints.

With these benefits, wireless technology is being revolutionized by inventing miniaturized multi-purpose antenna designs for multi-band operations with suitable bandwidth, radiation patterns and polarization characteristics. An inclined growth of ICs with respect to size and weight are being reduced. Motivated by these improvements and scope, in this study, the effects of circularly based dual band antennas under multilayer architecture of the 5G networks are reviewed.

The highlights of this study are:

a) Summarizes the state-of -the- art of the Circular polarization antennas.
b) Explored the opportunities provided by the 5G networks
c) Explored the real-time challenges prevail in these CP antennas.

2. Literature Survey

This section presents the reviews of different types of antenna designs; energy minimization and power maximization algorithms used in 5G mobile generations. (Kush Agarwal et al, 2015) has discussed the role of Electro-Magnetic (EM) waves using biomedical implant antennas. The radiating structures of the EM waves have demonstrated the powering systems of far-field and the wearable endfire antennas. It has ensured a reliable communication link. The designed implantable antenna observed a resonated frequency of 2.45 GHz to 2.59 GHz. However, the impedance became worse.

Traffic aware cellular base stations was studied by (Faran Ahmed et al, 2018) that improved the energy saving systems. It was observed that the sudden climatic conditional change has increased the utilization of energy systems. Henceforth, an extreme base station was designed to minimize the conservation systems. In the case of dynamic systems, the harvesting rate of energy was maximized and also linearly increased the traffic. During the antennas, power consumption

incurred in DC-DC power supply, the power consumed by single and group of transceivers were equally consumed. Based on the antenna transmission, linear relationship between the harvested energy and backup capacity. The advancements made in LTE (Ian F. Akyildiz et al, 2013) was studied for B4G systems. The key enabling technologies like Rel-10 and Rel-11 were discussed for exploiting the wireless traffic systems. Along with that, MIMO technologies in terms of LTE were presented. It was observed that the performance of the network system depends on the utilization of bandwidth. In order to increase the flexibility of the LTE advancements was explored to utilize the frequency bands on the count of users. The research challenges such as backhaul; feedback from channel information; design of reference signals; and power controls were to be addressed.

Coverage improvement factors in antennas with millimeter (mm) wave frequencies was studied to maximize the energy efficiency (Mario Alonzo et al, 2018). The non-convexity problems were discussed using hybrid analog/digital beamformers. Power control algorithm was optimized by the dimensional matrix of the communication protocols. The beamforming capabilities of the antennas with uplink and downlink transmit power were generalized. Though it has yielded better CSI performance, the heavy loaded and converged solutions are not discussed. To increase the operational expenditures and the gain rate of the cellular networks, energy saving systems play a vital role (Mohammed H. Alsharif et al, 2013). Base station consumes more energy than the other network entities. Henceforth, the participation of green radio communication networks was explored to enhance the energy-oriented techniques such as, energy-efficient power amplifier techniques, time-domain techniques, cell switching, management of the physical layer through multiple-input multiple-output (MIMO) management. The use of energy was explored from three levels, namely, facility; equipment and the networks. The participation of the data centers in terms of energy metrics was neutralized under time-domain parameters. During the process of cell switch off/on, a proportionate amount of energy utilized and thus, optimization approach. Irrespective of this, mobile coverage during the handover process requires more detailed description on the antenna design.

Cellular design, in specific to antennas, to revolutionize the greener LTE field was explored by (Mohammed H. Alsharif et al, 2013). Intelligent management techniques were discussed to cover up the challenges of the cell switching; cell zooming and the mobile operator. By the help of multiple transceivers, radio frequency and the baseband systems, the power components are stabilized. It is a well-known fact that the power amplifier consumes more energy which was improved in this study. Therefore, reduced numbers of antennas were used to enhance the performance of the power amplifier. However, in the case of heterogeneous network deployment, the design and usage of the antenna needs to be studied. The design and developments of the communication systems was explored (Mohammed H. Alsharif et al, 2013) in terms of green mobile networks. Price and sustainability are the motivating factors of energy-preserving technologies. With the help of the 5G cellular networks, renewable energy has resolved the most

challenging issues. A cross-layer approach was designed on physical and MAC link layers. MIMO with two antennas still needs to cover the challenges like robustness, architectural flexibility, asynchronism and rate of convergence.

User activity detection is one of the fields that helps to increase the deployment of femtocells. The femtocells based base station was designed to improve the switch off in radio transmissions and the associated processing (Imran Ashraf et al,2010). In order to reduce the traffic in the voice model of a voice call, 37.5% power consumption was reduced. During the idle mode of the femtocell, a low power radio sniffer was considered to minimize the signaling overheads. Depending on the placement of antennas and the femtocell base station, the events were detected. In some cases, the idle users are not eliminated. GSM based mobile handsets were introduced to enhance the modulation of the edge network (Oleksandr Gorbachov, 2010). Due to the leakage of the current, the lengthening of the transistor channel in antennas was also extended. Though it has minimized the fabrication of multi-gate devices. The effects of polarized molecules between the position under voltage have also scrutinized. The contribution of the acoustic echoes developed an unexpected sound which was improved by stereo codec implementation.

Carrier aggregation for LTE advanced was introduced to improve the coverage and throughput by preserving the energy system (Basel Barakat et al, 2015). The quality of downlink using OFDMA was improved by designing carrier aggregation techniques on the transmitting antennas. The objective of this study was to improve the consumption rate of the power. It was explored on the single cell and the multi-cell scenarios. To extract the useful information from the mobile edges, a circularized pole antenna was deployed. This has increased the user activation rate to the proportion of the cell areas. Compared to the single sub-carrier power transmission, the cell radius and the carrier bandwidth were significantly increased. While this model is in the multi-carrier, it does not fit-in the application requirements. High efficiency of the power amplifiers was studied by modulating the operational modes (Andrei Grebennikov, 2011). The class F power amplifiers were discussed under frequency and harmonic load impedances. In order to control the voltage and the current waveforms in open-circuit systems, the efficiency of the output devices was ensured. During the harmonic generation process, the high impedance conditions were varied to find the behavior of the electric waveforms. However, the loading factor has deprived the voltage drop for second-order harmonics.

An optimal design of MIMO systems(Emil Bjornson et al, 2015) was designed to enhance the energy efficiency systems. Uplink and the downlink under different processing capabilities was discussed. The transmit power increases with the usage of antennas. Under single-cell scenarios and Zero-Force (ZF) processing, the interference suppression model was designed. Each antenna near the user equipment has to be subjected to the SINR values. The experimental results have given stabilized signals with better energy efficiency. However, the system becomes more complicated in the case of open-circuit systems. The deployment of small cell networks has

increased the backhaul issues which depleted the energy rate. Henceforth, a green small cell network (Lei Chen et al, 2016) was studied under FD and MIMO technologies. A novel precoding scheme was introduced to remove the issues from inter-tier and multi-user interference. In order to optimize the energy arrival rate and the battery usage, it was resolved under a non-convex problem. Self-backhaul model was designed by tuning the convex parameters. With the help of single -antennas scheme, it has broadened the backhaul link rate with multiple data streaming transmission. Though it defends the inter-tie interference, the use of MBS antennas are higher.

The exploration of the joint macrocell and the residential picocell was studied to enhance the performance of the macrocellular technologies (Holger Claussen et al, 2008). The role of antennas play a vital part in the macrocellular technologies. Coverage of the installed picocells has been analyzed to improve the efficiency in terms of active users. In the case of macrocells, the reduced number of users has influenced the data rate services. The RF based power amplifier which is placed near the antenna has increased the connectivity. Behind every antenna element, feed networks were used to increase the efficiency. Though it has increased the reliability, the sensitivity between amplifier and the antenna is not discussed in this study. Device to Device communications in cellular spectrum has increased the scope of user equipment (Gabor Fodor et al, 2012). It has covered the challenges in 3GPP such as energy; interference and the network interaction module. With the help of radio access networks and the posteriori device discovery process, the engagement of users was increased. Monte Carlo experiment done on power maximization has been done by measuring the probability of target capacity. This system has avoided the support of multi-antenna transmission models due to the cost sensitivity.

Cognitive radio networks play a vital role in the network communication system. It manages the communication medium in configuration, optimization, and healing (Vassilis Foteinos et al, 2013). The developments made in cognitive technologies lack flexibility and interoperability. To increase the performance user based applications, it combines with the opportunistic routing networks. It was tested on the prototype platform and achieved a minimized execution time and the reduced usage of data bytes. These are accomplished to increase the various components' frameworks. In some scenarios, unavailability of the VOs has lowered the performance of the system. Data aggregation in cooperative based MIMO systems (Yi Gai et al, 2007) has been discussed under cellular technologies. The communication between users and the base station were projected as a non-linear programming problem. Lifetime of the network has been enhanced using data aggregation techniques. Power spectral density and the total effective noise during the antenna placement was modulated according to the application's objectives. The optimal constellation size was estimated from the varied communication distance. The minimized distance increases the network communication flow.

3. Comparative Analysis:

This section presents the recent techniques explored in the use of 5G networks. The table 1 provides the merits and demerits of the recent techniques. Energy efficiency, power minimization; resource efficiency etc., are the main research objectives of the most researchers.

Table 1

References	**Techniques**	**Merits**	**Demerits**
Adib Habbal et al, 2019	Context aware radio access technologies (Adib Habbal et al, 2019) was studied for smart city applications. Initially, the context of the user and the networks was renovated from RAT entities. The mathematical model of CRAT from user and network context were framed. Then, Analytical Hierarchical Process (AHP) was used to define the weights for each context. Then, the context with lowest weight using TOPSIS was taken for exploring the network analysis.	The increase of UEs has increased the packet delivery rate.	The flexibility of the network is not suitable for large scale applications.
(Xueying guo et al, 2016)	A delay constrained based optimized base station using sleeping control strategies was introduced. Closed form expressions were introduced to minimize the average power and delay distribution metrics. Thus, an energy based optimal base station was approached by simple bisection search.	With the help of Hetnets, the position of the base station was optimized.	The delayed constraints have brought the consequences of departing the queue length.
(Jie Gong et al,	Two stage dynamic programming algorithms	The effects of interference were	In some cases, an optimal bound is

2014)	discussed an energy-efficient wireless resource management system. In the grid environment, power consumption rate has been higher which was transformed into an unconstrained optimization problem. The relation between active subcarriers and the design of antennas contributed a major role.	reduced by tuning up the symmetric traffic distribution scenarios. The optimal solution was not possible by low-power background noise.	not possible to obtain the interference of neighboring cells. However, the number of active users is reduced.
(Abdennaceur Ghandri et al, 2018)	The analysis of bursty video traffic under LTE-Advanced Network was studied by Subframe Allocation Algorithm . A high proportion of bandwidth is being consumed in audio and video systems. Multimedia broadcast/multicast service (MBMS) allows for efficient use of network resources. In order to dynamically allocate the resources to the MBMS transmission model, a dynamic subframe allocation technique was designed.	Simulation results have shown the efficacy in terms of variable bit rate using LTE-SIM.	Though it has improved the system performance by achieving fair resource allocation, yet the linear prediction of multicast models deprived the network connectivity.
(Pimmy et al, 2017)	5G wireless communication networks using green technologies were reviewed to bring out the challenges related to the security system. Productivity oriented concepts such as device-to-device (D2D) communication, spectrum sharing, ultra-dense networks	The objectives of the 5G networks are to enhance the connectivity rate with 1000 times better network throughput rate under cellular framework. The use of relay nodes determines the data rates and also design of the antenna	However, the study did not present the consequences of the multiple relaying actions.

	(UDNs), massive MIMO, millimeter wave networks and the Internet of Things (IoT) were discussed.	ensures the network connectivity. The small cells are concentrated to optimize the power system.	
(Mingjie Feng et al, 2018)	Millimeter wave cellular system is one of the concepts that deals with the dynamic base station . Radio frequency is one of the motivating factors that deals with energy -efficiency systems. Since the base station is dynamic, there is a tradeoff between the data collection and the energy consumption. Sleep control of dynamic BS and RF chain activation was done to enhance the efficient use of multi-cell millimeter wave cellular systems.	Along with the use of linear programming and the greedy algorithm, an optimal performance was achieved in terms of reducing the data rate.	When the density of users increases, mm wave systems display a network issue.
(Waleed Ejaz et al, 2020)	Resource allocation of CRAN under 5G systems was surveyed to bring out the challenges given by the user assignment, power allocation, and spectrum management concepts . The variants of CRAN such as heterogeneous CRAN, millimeter-wave CRAN, virtualized CRAN, Non-Orthogonal Multiple Access (NoMA)-based CRAN and full-duplex enabled CRAN were discussed.	The quality of the 5G networks are determined from the deployment of antennas and also enhance the performance of multi-antennas under different scenarios.	Backhaul constraint and the utilization maximum are to be focussed in the 5g networks.

(Hamid Eltom et al, 2018)	Spectrum capability is one of the concepts that hinders the performance of the 5G networks . The analysis of primary and secondary users has guaranteed the avoidance of interference and the seamless communications. Channel availability determines the efficiency of the spectrum utilization.	In order to minimize the time delay, the availability of the channel is the most important. With the help of bayesian calculation, spectrum models and the parameters were tuned up. Kernel density estimation with class size and statistical regressions were used to obtain convergence solutions in terms of redundancy loss and the spectrum occupancy.	However, cooperative spectrum prediction is not studied.
(Youngbok Cho et al, 2018)	Smart healthcare systems are introduced with the help of smartphone technologies . IoT based wireless technologies have been invented to smoothen the communication networks. The network route was improved by following Omnidirectional antennas.	In order to stabilize the network communication protocols, the network capabilities of the mobile handsets have to be studied.	The random placements of nodes have increased the energy consumption rate, since it took long-running time.
(Elias Chavarria-Reyes et al, 2015)	Multi-layer heterogeneous systems were studied to minimize the energy consumption rate using HetNets . The energy consumed by spatio-temporal traffic and the internal base station are higher. This problem was projected as a 0-1 Knapsack-like problem. Cell-activation and cell-association under m-layer were analyzed by varying the	And also, varying the power amplifier rates, the operating functions microcell and macrocell were executed.	System has achieved a minimized rate of 69% energy utilization, though, the interference occurring in the m-layers is not discussed.

	locations		

4. Research gaps:

Circular polarization is a key factor that differentiates the waves generated from the transmitter and receiver of the antenna systems. The applications of Circular Polarization have been utilized in different sectors such as radar systems; scanners; earth stations and satellite systems. The effects of circular polarization can be explored from the methods like helical; spiral and multilayer based antennas. Sequential rotation technique is one of the methods that displays the effects of CP generated from placement of angular and phase based antennas. Linearly polarized antennas related to CPs prevail in two modes, namely, reflection mode and the transmission mode. Along with that, a combination of waveguide polarizers and the orthomode transducers are helping to enhance the performance of the 5G networks based applications.

a) Design of CPs:

The design of CPs antennas are developing a complex task with the effects of polarization. Based on the structure and topology of the antenna, the CPs wave requires special feeding techniques. Measurements such as bandwidth and the coverage are needed to be analyzed, so as to ensure that circular polarized operations are performing better in the applications. Suppose the beam of the antenna is very narrow, then the LoS association might bring the long sight to the satellite antenna. Henceforth, the placing (or) location of the antenna plays a vital role in the communication process. How wider the coverage, the communication flow can be increased.

b) Patched/ Etched structure:

Patching based metal shaped will act as the top of the dielectric layer. It shatters the coding of the obtained information. Hence, it makes use of some filter designs. Though it makes use of similar shapes, the size of the coverage is varied. Therefore, an immovable position of patched elements should be considered with high gain antenna structure.

c) Tag based antennas:

Planar monopole type antennas are being widely adopted under microstrip and CPs tag based antennas. It helps to increase the capacity of the bandwidth under resonating circuitry. It makes use of an RFID interrogator for signal transmission. It employs feedline and the radiation patch structure. Different frequency ranges are obtained from different radiation patterns. The fundamental shapes adopted are rectangular, modified rectangular, disc(circular), elliptical disc, and apple-shaped. In alignment with the interrogator antenna, the tag based antennas composes a

cross polarization model that reduces the interference between the signals.

d) Usability of the antennas:

Usability is the most important term that determines the efficiency of the designed antenna. Several studies have stated that the rationalized use of antennas has increased the market expenses, regardless of it, most designs are still progressing due to the application sensitivity (or) application requirement. Some instances such as monitoring and the sensing applications are troubled by the causes of sudden climatic conditions. Therefore, the broader use of circularly polarized antennas should be further investigated. Under 5G frameworks, smart cities; smart homes and healthcare systems are refining with tag based antennas.

e) Incorporation of sensing technology:

In many cases, fully printable CPs are applied under low cost and versatile materials. This causes big hurdles towards the fabrication technologies that explore novel printing technologies. The achievement of high bit capacity with limited resources brings design oriented challenges. Literature states that resonators, splits, slots and the concentric loops are continuously refined to enhance the data bits. Still, this challenge needs to be addressed for many compact and high bit demand applications.

f) Coupling of Electromagnetic waves (EM):

Under the closer proximal region, the coupling of EMs are analyzed to enhance the performance of the information coding process. It destroys the accuracy of the collected information. Thus, a secured, sensitive and confidential data related to the real-time applications have to be researched properly.

g) Propagation, attenuation and penetration of the antenna designs under 5G framework:

A considerable effort has been given by 3G and 4G cellular technologies which intends to overcome the limitation of data speeds. It helps to boost the network speed; network capacity and channel bandwidth. Few applications make frequent use of LTE networks to increase the network capacity by reducing the interferences. It also increases the experiences of the active users.

5. Conclusion

The developments made in the wireless communication systems have activated the growth of the several areas of communication research. The term wireless under a communication framework makes use of electromagnetic waves to carry over the signals on the communication

path. In this paper, we present the review of a circularly polarized antenna for multilayer 5G mobile phones. The goal of this paper is to display the research challenges prevailing in this field by reviewing the existing techniques. Initially, the scope of the 5G networks are discussed. The fundamentals of the circular polarization and its benefits are also explained in this study. Then, the existing techniques explored in this field are reviewed from the aspects of merits and the demerits. From the conducted reviews, the challenges in the functional key areas are CPs design; Patch/etched structure; tag based antennas; usability; incorporation of sensing technology; coupling of EM waves and propagation, attenuation and penetration using 5G networks. These areas need to be further investigated (or) the antenna system should be designed by overcoming the above mentioned challenges.

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